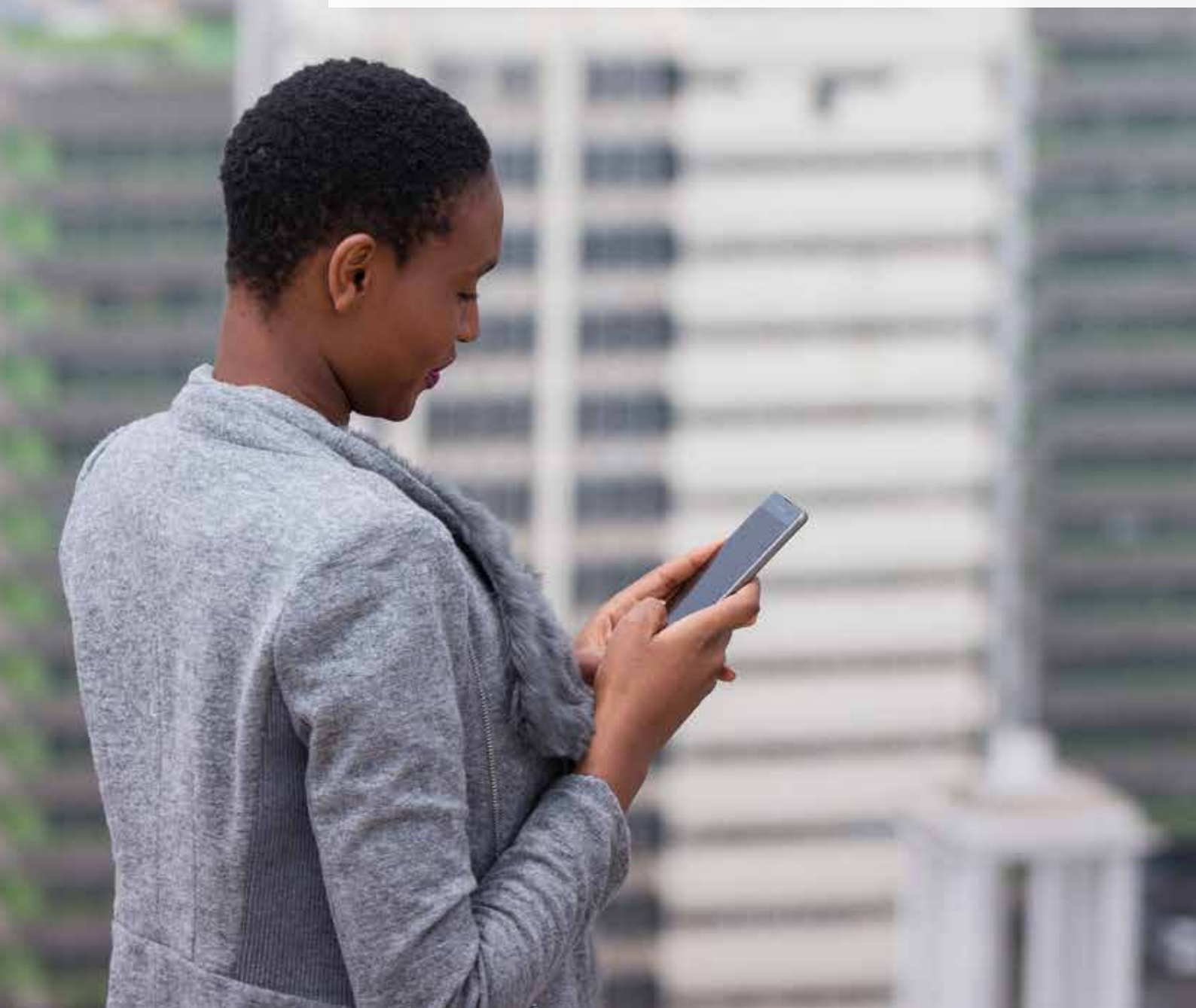
McKinsey&Company

MCKINSEY GLOBAL INSTITUTE

SMART CITIES: DIGITAL SOLUTIONS FOR A MORE LIVABLE FUTURE

JUNE 2018

EXECUTIVE SUMMARY



MCKINSEY GLOBAL INSTITUTE

Since its founding in 1990, the McKinsey Global Institute (MGI) has sought to develop a deeper understanding of the evolving global economy. As the business and economics research arm of McKinsey & Company, MGI aims to provide leaders in the commercial, public, and social sectors with the facts and insights on which to base management and policy decisions.

MGI research combines the disciplines of economics and management, employing the analytical tools of economics with the insights of business leaders. Our "micro-to-macro" methodology examines microeconomic industry trends to better understand the broad macroeconomic forces affecting business strategy and public policy. MGI's in-depth reports have covered more than 20 countries and 30 industries. Current research focuses on six themes: productivity and growth, natural resources, labor markets, the evolution of global financial markets, the economic impact of technology and innovation, and urbanization. Recent reports have assessed the digital economy, the impact of AI and automation on employment, income inequality, the productivity puzzle, the economic benefits of tackling gender inequality, a new era of global competition, Chinese innovation, and digital and financial globalization.

MGI is led by three McKinsey & Company senior partners: Jacques Bughin, Jonathan Woetzel, and James Manyika, who also serves as the chairman of MGI. Michael Chui, Susan Lund, Anu Madgavkar, Jan Mischke, Sree Ramaswamy, and Jaana Remes are MGI partners, and Mekala Krishnan and Jeongmin Seong are MGI senior fellows.

Project teams are led by the MGI partners and a group of senior fellows, and include consultants from McKinsey offices around the world. These teams draw on McKinsey's global network of partners and industry and management experts. Advice and input to MGI research are provided by the MGI Council, members of which are also involved in MGI's research. MGI council members are drawn from around the world and from various sectors and include Andrés Cadena, Sandrine Devillard, Richard Dobbs, Tarek Elmasry, Katy George, Rajat Gupta, Eric Hazan, Eric Labaye, Acha Leke, Scott Nyquist, Gary Pinkus, Sven Smit, Oliver Tonby, and Eckart Windhagen. In addition, leading economists, including Nobel laureates, act as research advisers to MGI research.

The partners of McKinsey fund MGI's research; it is not commissioned by any business, government, or other institution. For further information about MGI and to download reports, please visit **mckinsey.com/mgi.**

Copyright © McKinsey & Company 2018

SMART CITIES: DIGITAL SOLUTIONS FOR A MORE LIVABLE FUTURE

JUNE 2018

Jonathan Woetzel | Shanghai
Jaana Remes | San Francisco
Brodie Boland | Washington, DC
Katrina Lv | Shanghai
Suveer Sinha | Mumbai
Gernot Strube | Munich
John Means | Washington, DC
Jonathan Law | New York
Andrés Cadena | Bogotá
Valerie von der Tann | Berlin

IN BRIEF

SMART CITIES: DIGITAL SOLUTIONS FOR A MORE LIVABLE FUTURE

After a decade of experimentation, smart cities are entering a new phase. Although they are only one part of the full tool kit for making a city great, digital solutions are the most powerful and cost-effective additions to that tool kit in many years. This report analyzes dozens of current applications and finds that cities could use them to improve some quality-of-life indicators by 10–30 percent. It also finds that even the most cutting-edge smart cities on the planet are still at the beginning of their journey.

- Smart cities add digital intelligence to existing urban systems, making it possible to do more with less. Connected applications put real-time, transparent information into the hands of users to help them make better choices. These tools can save lives, prevent crime, and reduce the disease burden. They can save time, reduce waste, and even help boost social connectedness. When cities function more efficiently, they also become more productive places to do business.

- MGI assessed how dozens of current smart city applications could perform in three sample cities with varying legacy infrastructure systems and baseline starting points. We found that these tools could reduce fatalities by 8–10 percent, accelerate emergency response times by 20–35 percent, shave the average commute by 15–20 percent, lower the disease burden by 8–15 percent, and cut greenhouse gas emissions by 10–15 percent, among other positive outcomes.

- Our snapshot of deployment in 50 cities around the world shows that wealthier urban areas are generally transforming faster, although many have low public awareness and usage of the applications they have implemented. Asian megacities, with their young populations of digital natives and big urban problems to solve, are achieving exceptionally high adoption. Measured against what is possible today, even the global leaders have more work to do in building out the technology base, rolling out the full range of possible applications, and boosting adoption and user satisfaction. Many cities have not yet implemented some of the applications that could have the biggest potential impact. Since technology never stands still, the bar will only get higher.

- The public sector would be the natural owner of 70 percent of the applications we examined. But 60 percent of the initial investment required to implement the full range of applications could come from private actors. Furthermore, more than half of the initial investment made by the public sector could generate a positive return, whether in direct savings or opportunities to produce revenue.

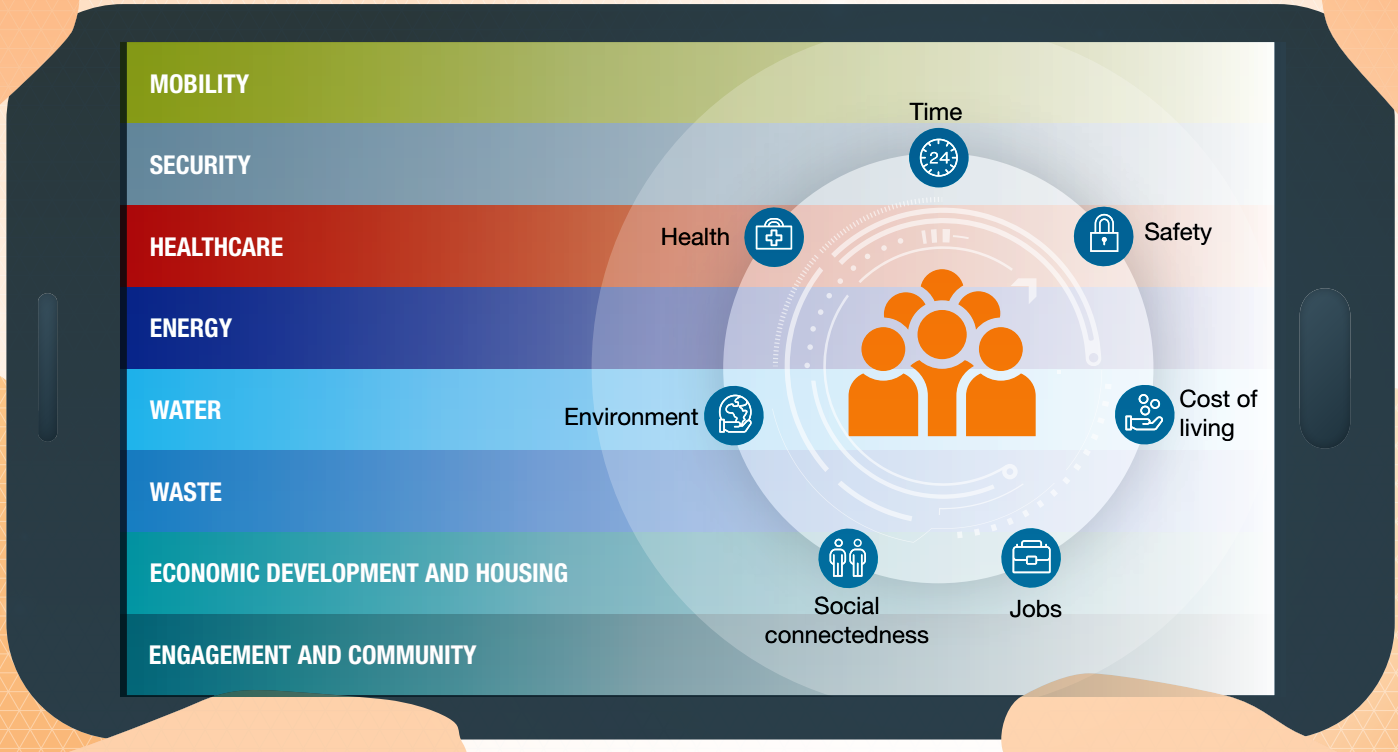
- The technologies analyzed in this report can help cities make moderate or significant progress toward 70 percent of the Sustainable Development Goals. Yet becoming a smart city is less effective as an economic development strategy for job creation.

- Smart cities may disrupt some industries even as they present substantial market opportunities. Customer needs will force a reevaluation of current products and services to meet higher expectations of quality, cost, and efficiency in everything from mobility to healthcare. Smart city solutions will shift value across the landscape of cities and throughout value chains. Companies looking to enter smart city markets will need different skill sets, creative financing models, and a sharper focus on civic engagement.

Becoming a smart city is not a goal but a means to an end. The entire point is to respond more effectively and dynamically to the needs and desires of residents. Technology is simply a tool to optimize the infrastructure, resources, and spaces they share. Few cities want to lag behind, but it is critical not to get caught up in technology for its own sake. Smart cities need to focus on improving outcomes for residents and enlisting their active participation in shaping the places they call home.

Smart cities use data and technology to make better decisions.

Smart applications in eight domains affect multiple aspects of the quality of life



The result?

A more efficient, responsive, and sustainable city . . .

. . . that delivers better outcomes for the people who call it home

30–300
lives saved each year in a city of 5 million

30–40%
fewer crime incidents

8–15%
lower disease burden

15–30
minutes shaved off the daily commute

25–80
liters of water saved per person per day

20–35%
faster emergency response times

MCKINSEY GLOBAL INSTITUTE

McKinsey&Company

Linie Ziel Abfahrt in
M1 Niederschönhausen Schillerstr. 8 min
12 Weißensee Pasedagplatz 16 min
.ee, Pasedagplatz. Bitte die Aushänge
S+U-Bahnhof Friedrichstraße

© Hinterhaus Productions/DigitalVision/Getty Images

EXECUTIVE SUMMARY

Until recently, city leaders thought of smart technologies primarily as tools for becoming more efficient behind the scenes. Sensor data and high-tech command centers promised a revolutionary new way to manage complex operations and automate infrastructure systems.

Now technology is being injected more directly into the lives of residents. Smartphones have become the keys to the city, putting instant information about transit, traffic, health services, safety alerts, and community news into millions of hands.

After a decade of trial and error, municipal leaders are realizing that smart city strategies start with people, not technology. “Smartness” is not just installing digital interfaces in traditional infrastructure or streamlining city operations. It is about using technology and data purposefully to make better decisions and deliver a better quality of life.

Quality of life has many dimensions, from the air residents breathe to how safe they feel walking the streets. Dozens of digital applications address these kinds of practical and very human concerns. We find that cities could improve some key quality-of-life indicators by 10–30 percent—numbers that translate into lives saved, reduced crime, shorter commutes, a lower health burden, and carbon emissions averted. Our research also examines the deployment progress made so far in dozens of cities around the world. It finds that even the most advanced cities still have a long way to go in building the fundamentals, implementing all of the available applications, and achieving wide adoption.

While good management is central to smart cities, municipal governments cannot do everything themselves. Companies and residents play an active role in shaping a city’s performance. Many smart city innovations are revenue-producing ventures from private-sector companies, and private actors could provide roughly 60 percent of the initial investment required to deploy the full range of current tools.

Centuries ago, Adam Smith observed that the actions of many self-interested parties combine to create larger benefits to society. Today a similar kind of “invisible hand” is at work in smart cities. When a company sees a revenue-producing opportunity to offer mobility services, residents in underserved neighborhoods suddenly have new ways to get to work. When a resident looks at real-time traffic data and decides to set out at a less busy time, she avoids adding another car to the road that would worsen congestion for everyone. Millions of individual decisions and actions add up, making the city as a whole more productive and responsive. But just as governments sometimes need to address the externalities caused by Adam Smith’s invisible hand, municipal leaders must choreograph the activity in a smart city, responding to unintended consequences and ensuring that everyone benefits.

The need is clear. Cities face unprecedented pressures as populations boom and infrastructure systems are stretched. Although cities concentrate societal problems, they are also the world’s best laboratories for solutions. Digital intelligence gives them a fresh set of tools for doing more with less.

WHAT MAKES A CITY SMART?

Smart cities put data and digital technology to work with the goal of improving the quality of life. More comprehensive, real-time data gives agencies the ability to watch events as they unfold, understand how demand patterns are changing, and respond with faster and lower-cost solutions.

In particular, smart technologies change the nature and economics of infrastructure. They reduce the cost of gathering information about usage patterns—and with an unprecedented volume of data points in hand, city governments, employers, and residents can find new ways to optimize existing systems. Some smart solutions both respond to demand and involve the public in shaping it. They encourage people to use transit during off-hours, to change routes, to use less energy and water and to do so at different times of day, and to reduce strains on the healthcare system through preventive self-care. The result is not only a more livable city but also a more productive place for businesses to operate.

Three layers work together to make a smart city hum (Exhibit E1). First is the technology base, which includes a critical mass of smartphones and other sensors connected by high-speed communication networks, as well as open data portals. Sensors take constant readings of variables such as traffic flow, energy consumption, air quality, and many other aspects of daily life and put information at the fingertips of those who need it.

The second layer consists of specific applications. Translating raw data into alerts, insight, and action requires the right tools, and this is where technology providers and app developers come in. Perhaps the best way to grasp what a smart city can be is to look at the full sweep of currently available applications (Exhibit E2). Tools are available in multiple domains: security, mobility, health, energy, water, waste, economic development and housing, and engagement and community.

The third layer is public usage. Many applications succeed only if they are widely adopted and manage to change behaviors. A number of them put individual users into the driver's seat by giving them more transparent information they can use to make better choices.

Exhibit E1

Smart cities add digital intelligence to the urban world and use it to solve public problems and achieve a higher quality of life.

Three layers of "smartness":
Adoption and usage, often leading to better decisions and behavior change
Smart applications and data analysis capabilities
The tech base includes networks of connected devices and sensors
Traditional infrastructure (physical and social)

SOURCE: McKinsey Global Institute

Exhibit E2

Our research looked at dozens of smart applications that will be relevant for cities through 2025.

SOURCE: McKinsey Global Institute

SMART CITY TECHNOLOGIES HAVE SUBSTANTIAL UNREALIZED POTENTIAL TO IMPROVE THE QUALITY OF LIFE

MGI gathered evidence and assessed how smart city applications could affect various quality-of-life dimensions: safety, time and convenience, health, environmental quality, social connectedness and civic participation, jobs, and the cost of living. We considered how effective these tools would be in distinct types of urban settings, assuming aspirational levels of adoption and best-in-class effectiveness based on case studies and research reports.

70%
of the Sustainable Development Goals can be advanced

We applied several criteria in deciding which tools to evaluate. First, they must be digital or data-based technologies. Second, they must be commercially available and already deployed in real-world settings. If they have only been piloted, large-scale rollout by 2025 must be feasible. Third, they must help solve a public problem. And finally, cities need to have a role to play, even in indirect ways such as encouraging adoption or setting regulation.

In many dimensions, we find that smart technologies could improve key indicators by 10–30 percent from the time they are introduced (Exhibit E3).[1] The needle may be moving already in cities that have implemented some of these tools, although all have room for additional improvement. The wide range of outcomes reflects the fact that applications perform differently from city to city, depending on factors such as legacy infrastructure systems and on baseline starting points. Nearly half of the applications affect more than one aspect of the quality of life. Intelligent traffic signals, for instance, not only improve mobility but also lower emissions and make roads safer. We also find that using the current generation of smart city applications effectively could help cities make significant or moderate progress toward meeting 70 percent of the Sustainable Development Goals.

Applications can help cities fight crime and improve other aspects of public safety

While public safety encompasses everything from emergency response times to effective safety inspections, anxiety about crime may be *the* foremost issue for residents of cities with high levels of violence. Technology is not a quick fix for crime, but agencies can use data to deploy scarce resources and personnel more effectively.

Up to
300
lives saved each year

Cities that deploy a range of applications to their maximum effect could reduce fatalities from homicide, road traffic, and fires by 8–10 percent. In a city with the population and crime profile of Rio, this could mean saving some 300 lives each year. Predictive policing, real-time crime mapping, and gunshot detection have the greatest impact on preventing deaths. Incidents of assault, robbery, and burglary could be lowered by 30–40 percent, with predictive policing, real-time crime mapping, and home security systems making the biggest difference. Optimized dispatching and synchronized traffic lights could cut emergency response times by 20–35 percent. On top of these metrics are the incalculable benefits of giving residents freedom of movement and peace of mind.

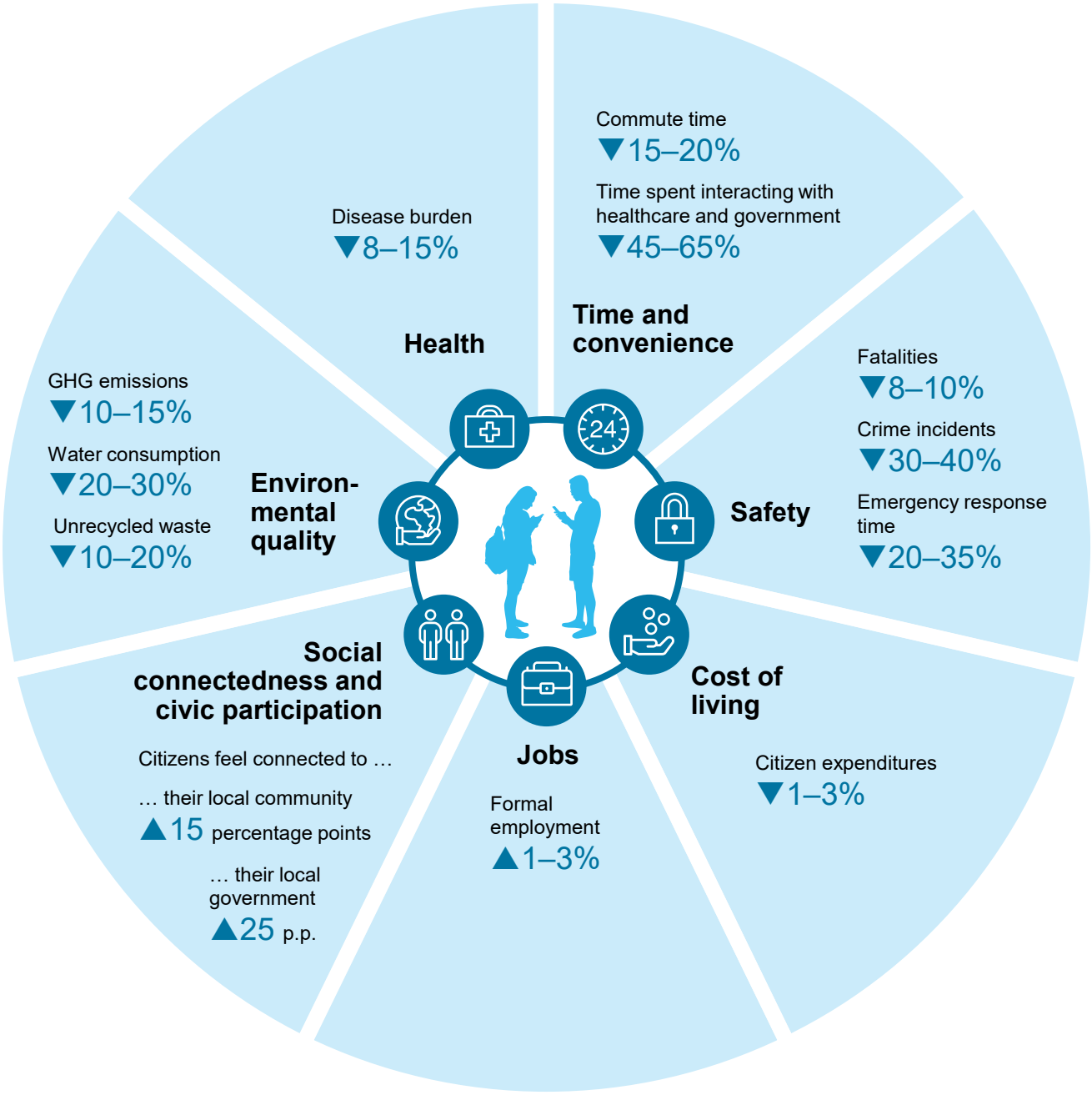
- **Crime and policing.** Digital tools are revolutionizing urban policing. Real-time crime mapping, for instance, utilizes statistical analysis to highlight patterns, while predictive policing goes a step further, anticipating crime to head off incidents before they occur. When incidents do occur, applications such as gunshot detection, smart surveillance, and home security systems can accelerate law enforcement response. But smart technologies in policing have to be deployed in a way that protects civil liberties and avoids criminalizing specific neighborhoods or demographic groups.

[1] These projections assume aspirational levels of adoption for each application and best-in-class effectiveness based on case studies and research reports.

Exhibit E3

Smart city applications can improve some key quality-of-life indicators by 10 to 30 percent.

Potential improvement through current generation of smart city applications, from time of implementation



SOURCE: McKinsey Global Institute analysis

- **Emergency response.** Seconds count when lives are at stake, making it critical to speed first responders to the scene of emergencies. Smart systems can optimize call centers and field operations, while traffic signal preemption gives emergency vehicles a clear driving path. A city with an already low response time of eight minutes could shave off almost two minutes. A city starting with an average response time of 50 minutes might be able to trim that by more than 17 minutes.

- **Traffic safety.** Some applications designed to improve mobility shift drivers to safer modes of transportation. We estimate that e-hailing can reduce traffic fatalities by more than 1 percent by reducing impaired driving. Widespread adoption of autonomous vehicles could one day make traffic safer, but many technical and real-world challenges will have to be met before that future becomes a reality.

Smart city technologies can make daily commutes faster and less frustrating

Tens of millions of people in cities as diverse as Jakarta, Bangalore, Rio, Nairobi, Seoul, and Atlanta begin and end every workday fuming in traffic or piling onto overcrowded buses and trains. Improving the daily commute is critical to the quality of life.

15–30 MIN
shaved off average daily commute

By 2025, cities that deploy smart mobility applications could cut commuting times by 15–20 percent on average, with some people enjoying even larger reductions. The potential associated with each application is highly variable, depending on each city's density, existing transit infrastructure, and commuting patterns. In a city like New York, smart technologies save the average commuter almost 15 minutes a day. In a developing city with more grueling commutes, workers might gain 20 to 30 minutes every day.

- **Public transit.** In general, cities with extensive, well-used transit systems benefit from applications that streamline the experience for riders. Using digital signage or mobile apps to deliver real-time information about delays enables riders to adjust their routes on the fly. Installing IoT sensors on existing physical infrastructure can help crews perform predictive maintenance, fixing problems before they turn into breakdowns and delays. Collecting and analyzing data on public transit usage and traffic can also help cities make better decisions about modifying bus routes, installing traffic signals and turn lanes, adding bike lanes, and allocating infrastructure budgets. Many urban transit systems, such as those in Houston and London, are starting to go ticketless with digital payment systems. Some are going a step further by offering flat-rate mobility subscriptions that cover multiple modes of transportation. Helsinki's Whim mobile app, for instance, charges a monthly fee for unlimited use of any type of public transportation, plus a certain amount of taxi and ride-sharing use.

- **Traffic mitigation.** Applications that ease road congestion are more effective in cities where driving is prevalent or where buses are the primary mode of transit. Intelligent syncing of traffic signals could reduce average commutes by more than 5 percent in developing cities where most people travel by bus. Real-time navigation alerts drivers to delays and helps them choose the fastest route. Smart parking apps point them directly to available spots, eliminating time spent fruitlessly circling city blocks. Moscow implemented a variety of intelligent traffic management tools, which it combined with major investment in public transit and new parking policies. Since 2010, a million more private cars have been added to its roads, but average travel speeds through the city are still up by 13 percent.

Cities can be catalysts for better health

The sheer density of cities makes them a critical if currently underutilized platform for addressing health. Recognizing that the role of technology in healthcare is broad and evolving by the day, we analyze only digital applications that offer cities room to play a role. We quantify their potential impact on disability-adjusted life years (DALYs), the primary metric used by the World Health Organization to convey the global disease burden. It combines the effects of mortality and morbidity into a single number, reflecting not only years of life lost to early death but also productive and healthy life lost to disability or incapacity.

If cities deploy the applications included in our analyses to their fullest effect, we see the potential to reduce DALYs by 8–15 percent, depending on each location's starting point and its underlying public health challenges.

- **Improved chronic disease treatment.** Applications that help prevent, treat, and monitor conditions could make the biggest difference in the developed world. Remote patient monitoring systems, which take a proactive and preventive approach to treatment, have the potential to reduce the health burden in high-income cities by more than 4 percent. These systems use digital devices to take vital readings, then transmit them securely to doctors in another location for assessment. This data can alert both patient and doctor when early intervention is needed, heading off complications and hospitalizations.

- **The use of data to fight preventable diseases.** Cities can use data and analytics to identify demographic groups with elevated risk profiles and target interventions more precisely. So-called mHealth interventions can send out lifesaving messages about vaccinations, sanitation, safe sex, and adherence to antiretroviral therapy regimens. In low-income cities with high infant mortality rates, data-based interventions focused on maternal and child health alone could reduce DALYs by more than 5 percent. Developing cities can also achieve a 5 percent reduction by using infectious disease surveillance systems to stay a step ahead of fast-moving epidemics, as public health officials did during the 2016 Zika outbreak that spread from Rio to Miami.

- **New ways to engage with patients.** Technology can empower people to take charge of their own health, preventing disease rather than treating it after the fact. Louisville, Kentucky, for example, collected data from sensors attached to the inhalers used by asthma patients. This information is synthesized on a digital platform with personalized guidance about the precautions individuals can take. Telemedicine, which provides clinical consultations by videoconference, decreases the barriers to seeking treatment. It can be lifesaving in low-income cities with doctor shortages.

Smart cities can deliver a cleaner and more sustainable environment

25–80 LITERS
potential water saved per person, per day

As urbanization, industrialization, and consumption grow, environmental pressures multiply. While technology is only one option for addressing these issues, it can be a powerful one. Overall, our analysis finds that deploying a range of applications to the best reasonable extent could cut emissions by 10–15 percent, lower water consumption by 20–30 percent, and reduce the volume of solid waste per capita by 10–20 percent.

- **Greenhouse gas emissions.** In a city where structures are the major source of emissions, building automation systems can lower emissions by just under 3 percent if adopted in most commercial buildings and by an additional 3 percent if adopted in most homes. Another application with significant potential is dynamic electricity pricing, which allows utilities to charge more when demand peaks. By reducing consumption and shifting the load to off-peak periods, it reduces the power sector's use of backup "peaker plants" that produce more emissions. E-hailing and demand-based microtransit could significantly reduce emissions if fuel-efficient fleets offset more polluting alternatives. Intelligent traffic signals, congestion pricing, and other mobility applications also cut emissions from traffic.

- **Air quality.** Some of the energy-saving and mobility applications described above could improve air quality as a secondary benefit. To tackle this issue more directly, cities can install air quality sensors. They do not automatically address the causes of pollution, but they can identify the sources and provide the basis for further action. Beijing reduced deadly airborne pollutants by roughly 20 percent in less than a year by closely tracking the sources of pollution and regulating traffic and construction accordingly. Sharing real-time air quality information with the public via smartphone apps enables individuals to take protective measures, potentially reducing negative health effects by 3–15 percent, depending on current pollution levels.

- **Water conservation.** Water consumption tracking, which pairs advanced metering with digital feedback messages, can nudge people toward conservation. It could reduce consumption by 15 percent in a higher-income city where residential water usage is high, although its effectiveness depends on whether it is paired with a pricing strategy. In many parts of the developing world, the biggest source of water waste is leakage from pipes. Deploying sensors and analytics can cut those losses by up to 25 percent.

- **Solid waste reduction.** As low-tech recycling programs reach the limits of what they can do, technology could further reduce the volume of unrecycled solid waste. Digital tracking and payment for waste disposal, for instance, charges users for exactly for the amount and type of trash they throw away. But this type of application should be considered alongside other policy initiatives, particularly in developing economies where household budgets are tight and a great deal of informal recycling already takes place.

30–130 KG/PERSON
annual reduction in unrecycled solid waste

Smart cities can create a new type of digital urban commons and enhance social connectedness

Community is hard to quantify, but MGI surveyed urban residents to determine if digital applications can have an impact. Before using these applications, just 13 percent reported feeling connected to their local government and 24 percent said they felt connected to their local community. Our analysis suggests that the use of digital apps and platforms could nearly double the share of residents who feel connected to the local community, and nearly triple the share who feel connected to local government.

New channels for the public to communicate with local officials could make city governments more responsive. Many city agencies maintain an active presence on social networks, and others have developed their own interactive citizen apps. In addition to disseminating information, these channels create vehicles for residents to report concerns, collect data, or weigh in on planning issues. Paris has implemented a participatory budget, inviting anyone to post project ideas and then holding online votes to decide which ones merit funding.

Cities can be anonymous and impersonal places, and technology is often blamed for making daily life even more isolating. But some digital platforms facilitate interaction in the real world. Digital platforms such as Nextdoor invite neighborhoods to form online communities. They can strengthen ties between neighbors, mobilize action on specific issues, and provide support during emergencies. Applications like Meetup help users form groups with common interests, such as hobbies or sports, then organize offline get-togethers. Most applications that foster person-to-person connections are private-sector endeavors, but they can transform the way residents experience life in the city.

Smart city technologies do not create or destroy large numbers of jobs, but they can make local labor markets more efficient

Many local officials want to know if becoming a smart city will lead to an infusion of high-paying tech jobs or accelerate a wave of automation. Our analysis finds that smart technologies can play a role in making local job markets more efficient, supporting local business growth, and building skills that make people more employable.

We estimate that a range of smart city technologies could have a slightly positive net impact on employment, boosting it by 1–3 percent by 2025. This number combines the direct, indirect, and induced job effects stemming from several developments. First, smart city technologies will directly eliminate some jobs, such as administrative and field jobs in city government, while creating others such as maintenance roles, driving jobs, and temporary installation jobs. Second, e-career centers and digital hiring platforms can have a modest positive impact by creating more efficient mechanisms for hiring and drawing more unemployed and inactive people into the workforce. Third, data-driven formal education and

online retraining programs can enhance a city's pool of skills. Finally, digitizing government functions such as business licensing, permitting, and tax filing can free local enterprises from red tape, contributing to a more efficient and entrepreneurial business climate.

Smart cities can slightly lower the cost of living

Many of the world's most dynamic and desirable cities have serious housing shortages, driving up rents and home prices. Expanding the supply of housing can bring down those costs. In many places, bureaucracy bogs down land acquisition, environmental studies, design approvals, and permitting. Digitizing these processes can remove risks and delays, encouraging more construction. In addition, most cities have a surprising amount of land sitting idle that could be suitable for infill housing. Creating open-source cadastral databases can help to identify land parcels for development.

Smart applications produce savings in other areas, such as encouraging more efficient usage of utilities and the healthcare system. Home security systems, personal alert devices, and lifestyle wearables involve consumer purchases, but they offer value that many are willing to pay for. Mobility applications offer new value as well, although e-hailing may encourage people to take more rides than they once did. However, e-hailing and other sharing applications make it possible for some people to forgo private vehicle ownership.

Some residents are concerned that smart cities will become gentrified technology hubs where they are eventually priced out. But the applications we analyzed can deliver quality-of-life benefits without causing harm to the average person's wallet. In fact, we estimate that the average person could save as much as 3 percent on current annual expenditures.

EVEN THE MOST ADVANCED SMART CITIES STILL HAVE A LONG WAY TO GO

We took a snapshot of progress and deployment in 50 cities around the world, choosing a geographically broad sample of places with a reputation for being smart or stated ambitions to be. The selection includes a mix of high- and low-income locations as well as cities of varying density, infrastructure quality, and size. We analyzed each city's three layers of "smartness": its technology base, the applications it has introduced, and public adoption. Our intention is not to crown the world's smartest city but to show the full sweep of activity under way around the globe. The results show that even the most cutting-edge smart cities on the planet have more work to do.

High-income cities are continuing to build out the underlying technology base, while developing cities face a disadvantage

Among the cities with the most advanced technology bases are Singapore, New York, Seoul, Stockholm, and Amsterdam. All have ultra-high-speed communication networks and are in the process of launching 5G services. Seoul, for example, has some of the fastest Internet speeds in the world and an extensive LPWA network. These cities have also expanded their sensor base beyond what most of their global peers have achieved.

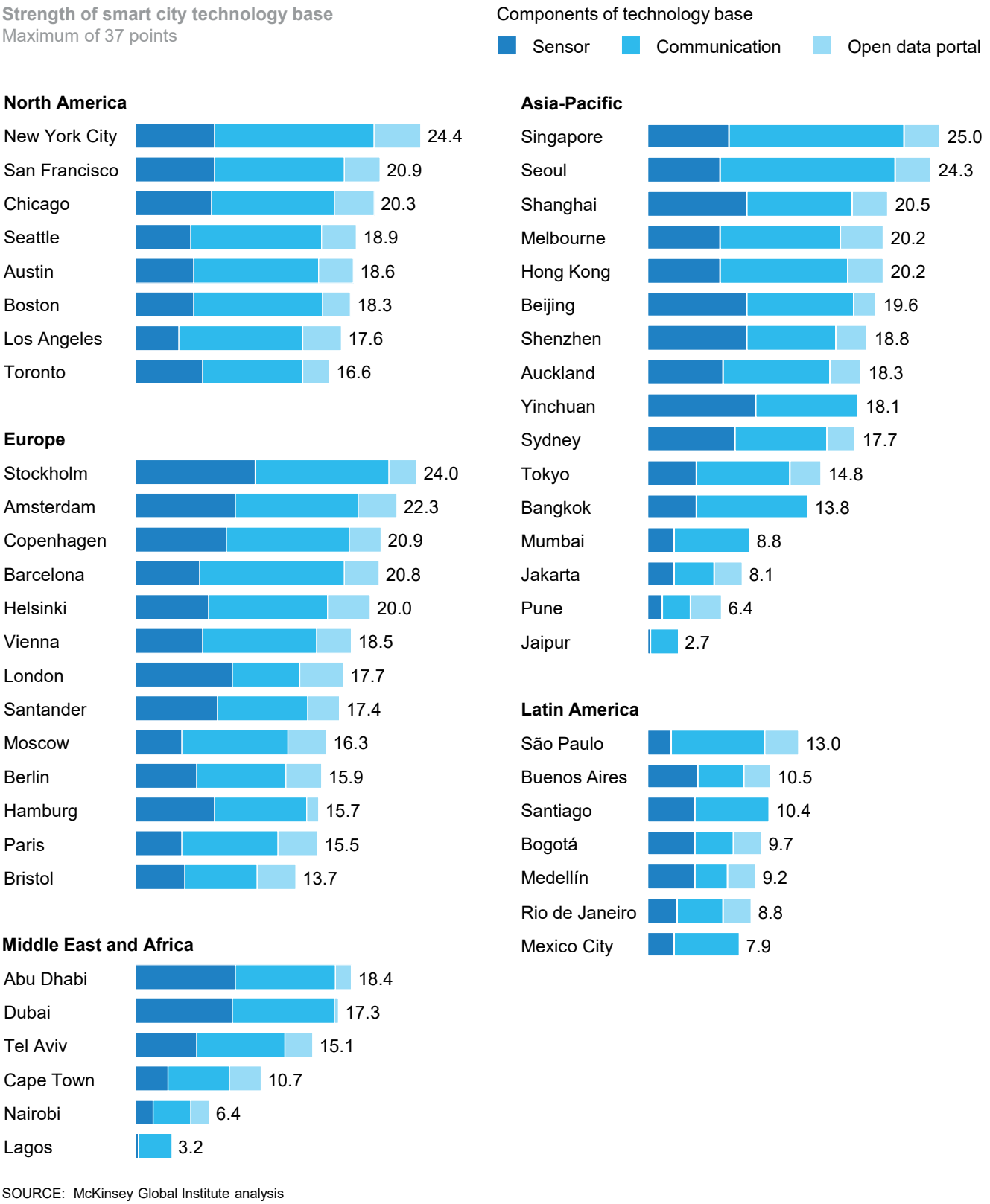
All cities have more upside potential. Even the most advanced cities are only about two-thirds of the way toward achieving what constitutes a fully comprehensive technology base today in terms of the extent of sensors and devices, the quality of communication networks, and the presence of open data portals (Exhibit E4). In general, cities across North America, Europe, China, and East Asia have relatively strong tech bases, as do select cities in the Middle East. But those in Latin America, Africa, and India lag behind, particularly in installing the sensor layer, the most capital-intensive element. Furthermore, there is a sharp contrast in smartphone penetration. Four high-income cities are in countries where smartphone penetration exceeds 90 percent, but seven low-income cities on our list are in countries where the penetration rate is 60 percent or lower. Most cities have open data portals. The handful of developing cities that do not could jump-start progress by creating them, since

they make raw information available for private-sector innovation that does not require public investment.

Exhibit E4

Cities in Europe, North America, China, and East Asia have the most developed technology bases, while those in Latin America, Africa, and India lag behind.

NOT EXHAUSTIVE



SOURCE: McKinsey Global Institute analysis

North American and Asian cities lead the way in application rollout

We gauged each city's progress in implementation using a checklist of current smart applications to see how many have been rolled out (Exhibit E5). We use a weighted composite of city-wide implementation as well as pilot programs.

Mobility has been a top priority for most cities, but those places with the highest number of applications implemented overall—New York, Los Angeles, London, Singapore, Shenzhen, and Seoul—have branched out into multiple domains. Extending the focus beyond mobility is what gets a city closer to setting off a virtuous circle of benefits. Some cities have not yet implemented the applications with the greatest potential to address some of their priority issues.

- **Mobility rollout.** Mobility is clearly the emphasis in European cities, which tend to have more modest implementation in other domains. Private-sector e-hailing services are available in all of the cities, although pooled versions of these services are not. Bike- and car-sharing applications are also present in almost all of these cities. By contrast, few places have adopted demand-based microtransit, predictive maintenance of public transit, or congestion pricing.

- **Security rollout.** Security applications have vaulted to the top of the priority list for cities with high crime rates, such as Rio, Cape Town, Mexico City, and Chicago. A clear majority of cities have at least piloted smart surveillance, real-time crime mapping, and outfitting police officers with body-worn cameras. Almost half are not yet using or even piloting digital applications to speed the dispatch of first responders to emergencies, and very few are conducting data-driven building inspections.

- **Health rollout.** North American cities tend to lead the way in smart healthcare applications. By contrast, the major cities of Africa, which have much to gain from applying technology to their public health challenges, lag far behind. Most cities have some air quality monitoring sensors in place, and telemedicine is being widely piloted. Yinchuan, for instance, has embedded digital healthcare services into its purpose-built smart communities. While most cities have full-scale infectious disease surveillance systems, a substantial number of developing cities do not. More than half of the cities we analyzed are not using data-based public health interventions.

- **Utilities rollout.** Cities with robust technology bases are doing more with utilities applications. Dubai has equipped its electricity network with smart meters and has achieved high adoption of home automation systems and behavior-based electricity consumption tracking. North American, Asian, and European capitals are in the forefront, while Latin American cities lag far behind.

- **Economic development, housing, and community engagement rollout.** Urban residents across the world have access to some kind of platform for making in-person connections. Cities are in varying stages of digitizing government, including their citizen-facing services. In the United States, Boston, Seattle, and other cities have developed 311 apps for nonemergencies such as reporting nuisances, potholes, and graffiti. Barcelona has created a digital platform that offers residents a way to weigh in on decision making. Although personalized learning platforms could play a large role in education and job retraining, this area remains largely unexplored.

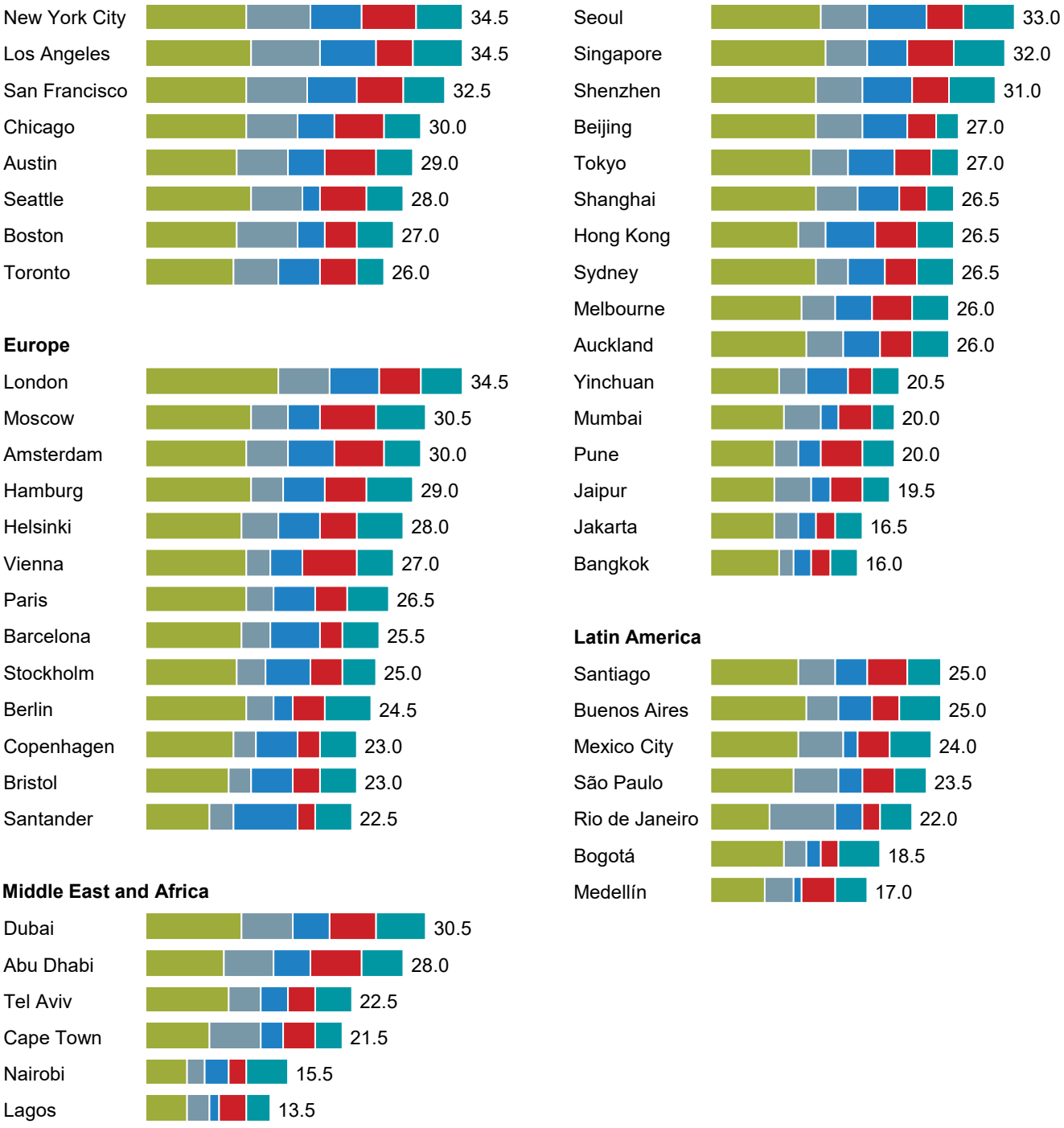
Exhibit E5

The cities deploying the greatest numbers of applications overall are moving forward in all domains.

NOT EXHAUSTIVE

Deployment of smart city applications
Maximum of 55 points

Applications
Mobility · Security · Utilities · Healthcare · Economic development, housing, and community



SOURCE: McKinsey Global Institute analysis

Our survey shows that a handful of Asian megacities are standouts in awareness and usage

Given the shift toward more people-centric smart cities, it is important to take stock of how residents feel about the technologies already at work in their environment. MGI conducted online surveys in all of the cities we analyzed.[2] Respondents were asked about their awareness of the applications in their city, whether they have used them, and how satisfied they were with the experience (Exhibit E6).

Asian cities are the strongest performers in awareness, usage, and satisfaction, while European cities lag. Positive adoption and awareness appear correlated with having a young population. While it is impossible to generalize about age, it seems that a greater share of the young population not only accepts a more digital way of doing things but expects it—and demands a seamless experience. Overall, people are most aware of and most likely to have used mobility applications, while applications related to utilities have less visibility.

SMART CITIES NEED SMART GOVERNMENT

Using technology to transform urban environments in a more meaningful way will require new thinking about governance. Technology is only as effective as the entity that puts it to work.

Combine smart planning with asset development to get the most out of the system

Smart city technologies help cities get more out of their assets, whether they have extensive legacy systems or are building from scratch. There is no getting around the need to invest in physical assets and maintenance, but smart technologies can add new capabilities as core components are upgraded.

Infrastructure investment once locked cities into capital-intensive and extremely long-term plans based on a static snapshot of how they expected demand to evolve. Now, using the right combination of traditional construction and smart solutions, they can respond more dynamically to how demand is changing. Governments can make more flexible, data-driven investments with shorter planning cycles. If population growth surges in a far-flung neighborhood, adding a new subway or bus line with the accompanying fleet expansion may take years. By contrast, a privately operated on-demand minibus service could be up and running much faster.

Smart city applications become more effective when paired with low-tech measures and complementary policy moves. Reducing private car use is a priority in Seoul, for example. In addition to implementing smart mobility solutions, the city is reallocating street lanes to pedestrians and bicycles, and strictly limiting parking spots in new public buildings.

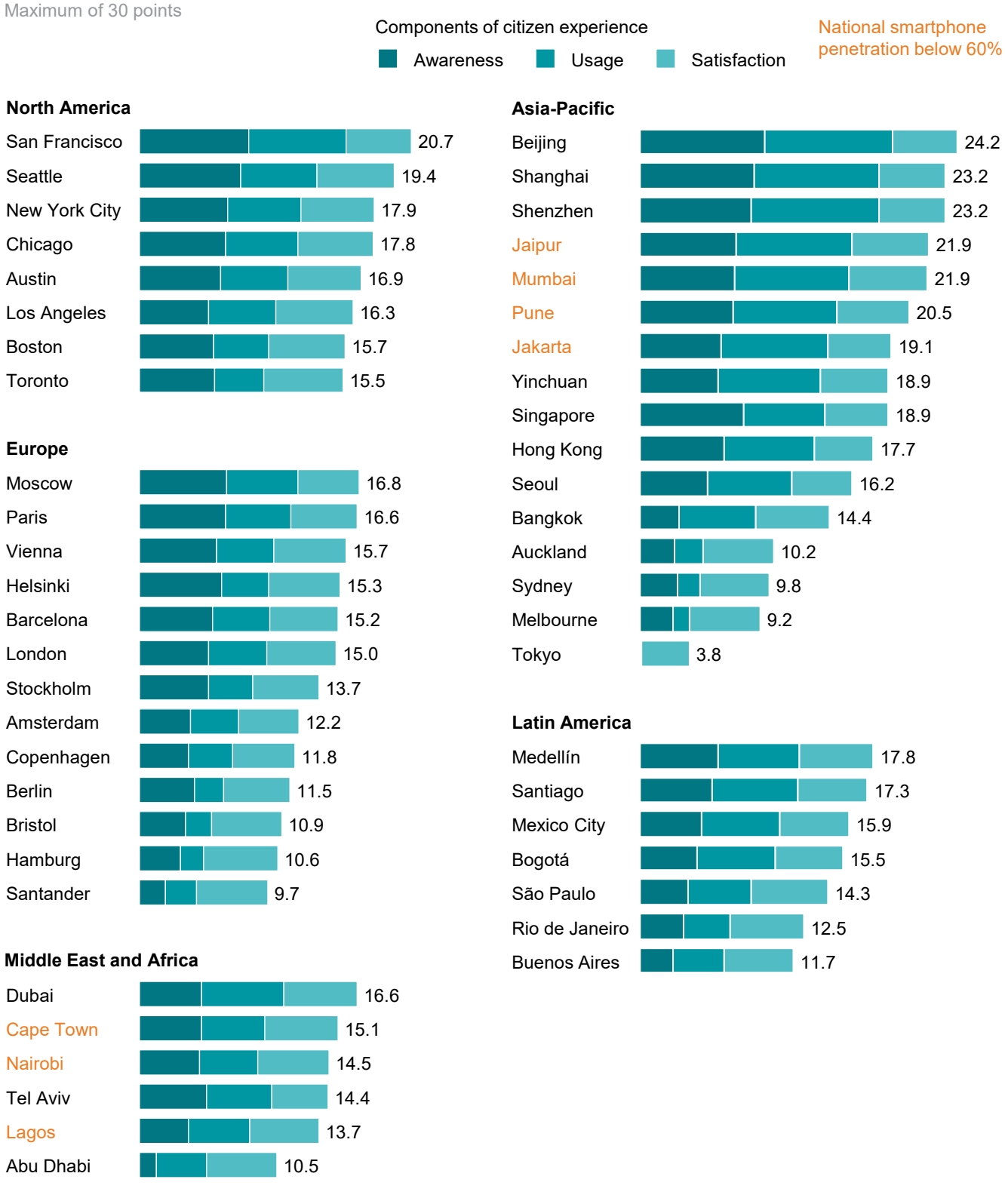
[2] Because these surveys were conducted online, the sample by its nature does not include offline populations. The survey results for cities with relatively low smartphone penetration must be interpreted in that light.

Exhibit E6

MGI surveyed local residents about the applications implemented in their cities.

NOT EXHAUSTIVE

Combined awareness, usage, and satisfaction scores
Maximum of 30 points



SOURCE: McKinsey Global Institute survey and analysis

Embrace an open approach to support innovation and private-sector participation

City government does not have to be the sole funder and operator of every type of service and infrastructure system. While implementing most of the applications we examined would fall to the public sector, the majority of the initial investment could come from private actors (Exhibit E7). Public financing may be reserved for only those public goods that must be provided by the government. Furthermore, more than half of the initial investment that needs to be made by the public sector would generate a positive financial return, which opens the door to partnerships.

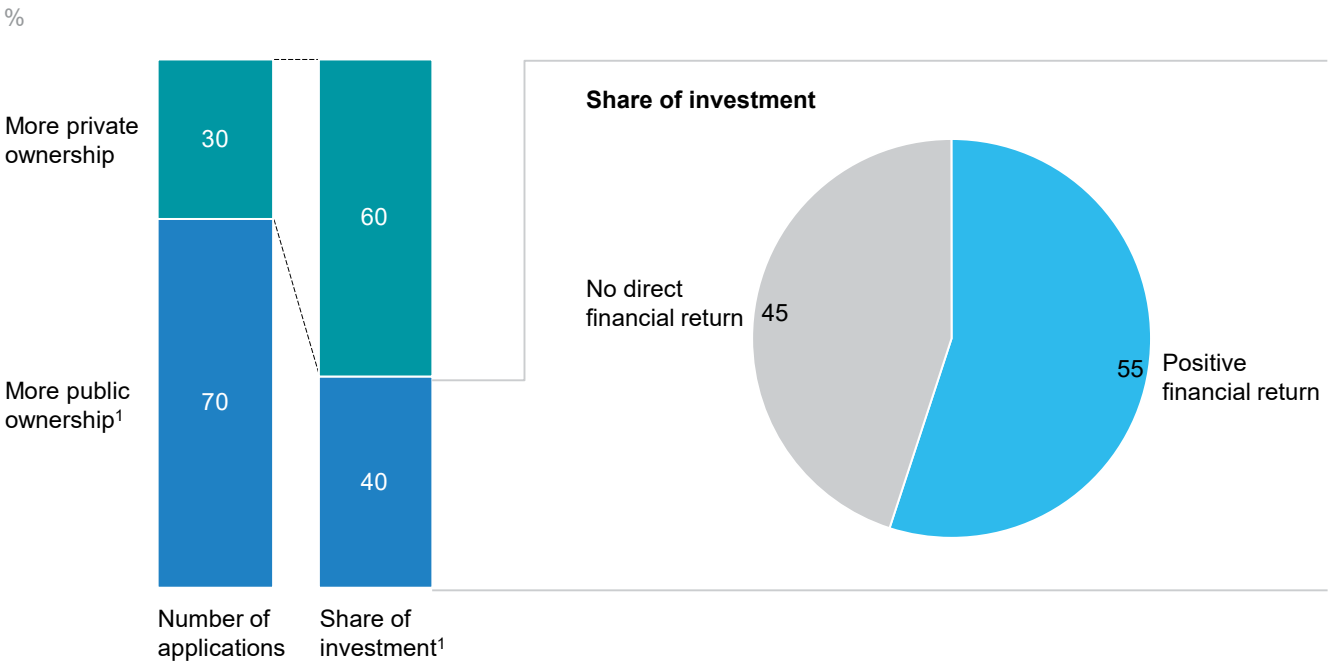
60%
share of initial investment that could come from private actors

It makes sense to identify areas where city agencies can step back and make room for private-sector companies, state-owned utilities, universities, foundations, and nonprofits to play a role. Adding more actors to the mix is a positive, since it increases adoption and applies more creativity to the available data. Cash-strapped municipal governments may need to enlist multiple partners, but the natural owner should add value such as expertise and capabilities, not just capital.

When private-sector innovations spring up organically, the role of government may involve regulating, convening key actors, offering subsidies, or changing purchasing decisions. Rather than taking a master-planning approach, some cities position themselves as ecosystems, creating consortia and even physical collaboration spaces. Amsterdam Smart City, for example, is a public-private partnership that brings together municipal agencies, educational institutions, nonprofits, private-sector companies, and startups.

Exhibit E7

The public sector would be the natural owner of most applications, but the majority of investment could come from private actors—and even many public-sector applications can generate returns.



1 Energy, water, waste utilities, public transport operators, and hospitals assumed public for this quantification, although this differs around the world.
NOTE: Autonomous vehicles excluded; technology has not been deployed at scale and required investment by 2025 not yet clear.

SOURCE: McKinsey Global Institute analysis

Put people at the center of everything, and use technology to unite the city

Technology can change the relationship between municipal governments and the people they serve. Constituents can engage in two-way conversations with public officials and agencies via social media and interactive mobile apps. Cities can use technology to take the pulse of public opinion on a wide range of issues, using public feedback as the basis for making continuous improvements to the system. To that end, smart city efforts need to be transparent and accountable to the public. Engaging residents from the outset, not just after specific applications suddenly appear, can secure community buy-in.

Smart cities also raise questions of equity. Most (though not all) applications require smartphones or work best with them, so bringing more of the population online is a priority. The needs of all demographics and neighborhoods should be on the agenda when cities choose which programs to pursue. There is an exciting opportunity to use technology to serve aging populations, for example. Cities such as Singapore and Tokyo are using applications such as remote patient monitoring and telemedicine to help seniors age at home.

Technology may have the potential to be alienating, but cities can turn that on its head by actively looking for ways to use it in the service of building real-world community and personal connection. They may be able to use social networks to facilitate volunteering, mentoring, parenting support, and community activities on a much wider scale, for example.

Add the skills and create the latitude to innovate across city agencies

Getting smart doesn't happen by itself. Cities need to give their agencies the leeway to innovate. Adding civic tech talent, at least in selective areas, is a top priority for municipal governments. Even if they rely on external providers, they have to be able to understand and direct the programs in detail. Many places have started by adding new roles such as chief digital officer or establishing cross-disciplinary smart city units. Boston, for example, has established an analytics unit, while Chicago has built a data science team. Over time, however, the effort to become smart must permeate every aspect of government.

In a digital world, city agencies need the latitude to make bolder decisions and to experiment, learn, and recalibrate. Smart cities such as Copenhagen approach that challenge by testing applications in pilot districts or living laboratories. In Kigali, Vision City is a tech-enabled district with free Wi-Fi, solar-powered streetlights and mobile networks, and new housing units complete with automation systems.

Get cybersmart to address privacy and security risks

Increased surveillance and data-driven policing raise concerns about "big brother" always watching and the potential to inhibit political dissent. Governments and private-sector players now hold and share sensitive personal data, making it critical to establish thoughtful protocols and safeguards about its handling and protection.

Experts worldwide are concerned about cybersecurity vulnerabilities in smart cities. The Internet of Things provides extensive "surface area" for hackers to attack. Compromised security systems, medical monitors, and self-driving cars could pose life-and-death risks, and the consequences could be severe if bad actors shut down a city's power grid or water supply. Cities need to prioritize their most sensitive assets and surround them with the most rigorous defense mechanisms. Mission-critical IoT applications should have high levels of security before they are adopted on a large scale. Cities will have to develop cybersecurity expertise, and stay abreast of the constantly evolving threat environment. They will need to prepare for how to respond to breaches—including not only technical remediation but how they will maintain calm and how they will communicate. IoT firms and mobile app

developers must prioritize cybersecurity at every stage rather than patching safeguards onto completed tools after the fact.[3]

FOR COMPANIES, SMART CITIES PRESENT LARGE MARKET OPPORTUNITIES AS WELL AS INDUSTRY DISRUPTIONS

Smart cities open up new business opportunities—and not only for technology firms. They will also reshape value chains and force companies to adapt. To set strategies, company leaders need to address key questions: How does the evolution of smart cities affect my current offerings? What kind of value shifts and opportunities will this create across my industry? And what type of approaches and capabilities does it take to succeed in these markets?

Adapt current offerings to meet smart city needs

Companies in multiple industries are already beginning to alter their existing product and service lines to suit changing urban markets. These include drugstore chains that are becoming telemedicine providers and real estate developers that are integrating automation systems, sensors, and mobility options into their properties.

Autonomous vehicles are not yet fixtures on the road, but carmakers are already adding features such as real-time road navigation and smart parking to the current generation of vehicles. Commercial trucks, too, will need to be able to connect to systems such as load pooling and urban consolidation centers. Although it is posting explosive growth in cities worldwide, e-hailing has relatively limited penetration with certain audiences—and new vehicle concepts could help e-hailing break through with them.

Prepare for value shifts and unexpected competitors

Land values are likely to shift as cities become smart, affecting real estate in multiple ways. Some formerly congested, polluted, or crime-ridden areas could become more livable, while new transit options could raise values in suburbs and exurbs. Older properties that lack smart features may not hold their value in the same way they once did, and developers have to weigh the costs of retrofitting them. Data can change the way properties are utilized as well as the way they are valued, and effective use of geospatial data will become a source of competitive advantage.

As cities get smarter, mobility has become a much more crowded playing field, with companies from different industries competing for a market with rapidly shifting value. Customer-facing mobility platforms such as Didi and Uber are big bets on the future, and now traditional automakers and even public transit operators are entering this space by offering multimodal platforms or their own ride-sharing services. Several major manufacturers are launching their own on-demand services using custom-designed fleets of minibuses. How automakers will respond when autonomous transportation services eventually break through remains to be seen. They may make and sell the required fleets, operate them as a service for other companies and cities, or successfully position their own mobility platforms.

Smart applications can play a role in shifting healthcare systems from treating illness to preventing it. Many healthcare applications aim to prevent diseases before they occur, engage patients in maintaining their own wellness, and reduce the likelihood of complications and hospitalizations. This trend could bring a huge upside for payors. Smart applications such as integrated patient flow management systems can improve the utilization of hospitals and specialized equipment without compromising on availability for patients. Convenient telemedicine options can absorb many patients with minor or

[3] For more on cybersecurity, see James Kaplan, *Beyond cybersecurity: Protecting your digital business*, Wiley, 2015; and "Six ways CEOs can promote cybersecurity," McKinsey.com, August 2017.

routine complaints, taking pressure off traditional healthcare facilities. New technologies in healthcare also bring in new entrants from the tech sector.

Adapt your approach and capabilities

Early smart city offerings were sometimes criticized as "throwing" off-the-shelf technology systems at cities. Today officials are savvier and not easily impressed with cookie-cutter approaches. Companies will need a detailed understanding of each city's context, including its problems, decision-making process, and regulatory landscape. Most sales organizations are not yet equipped with these types of capabilities. They may need to add urbanists, sociologists, and other specialists to broaden their thinking.

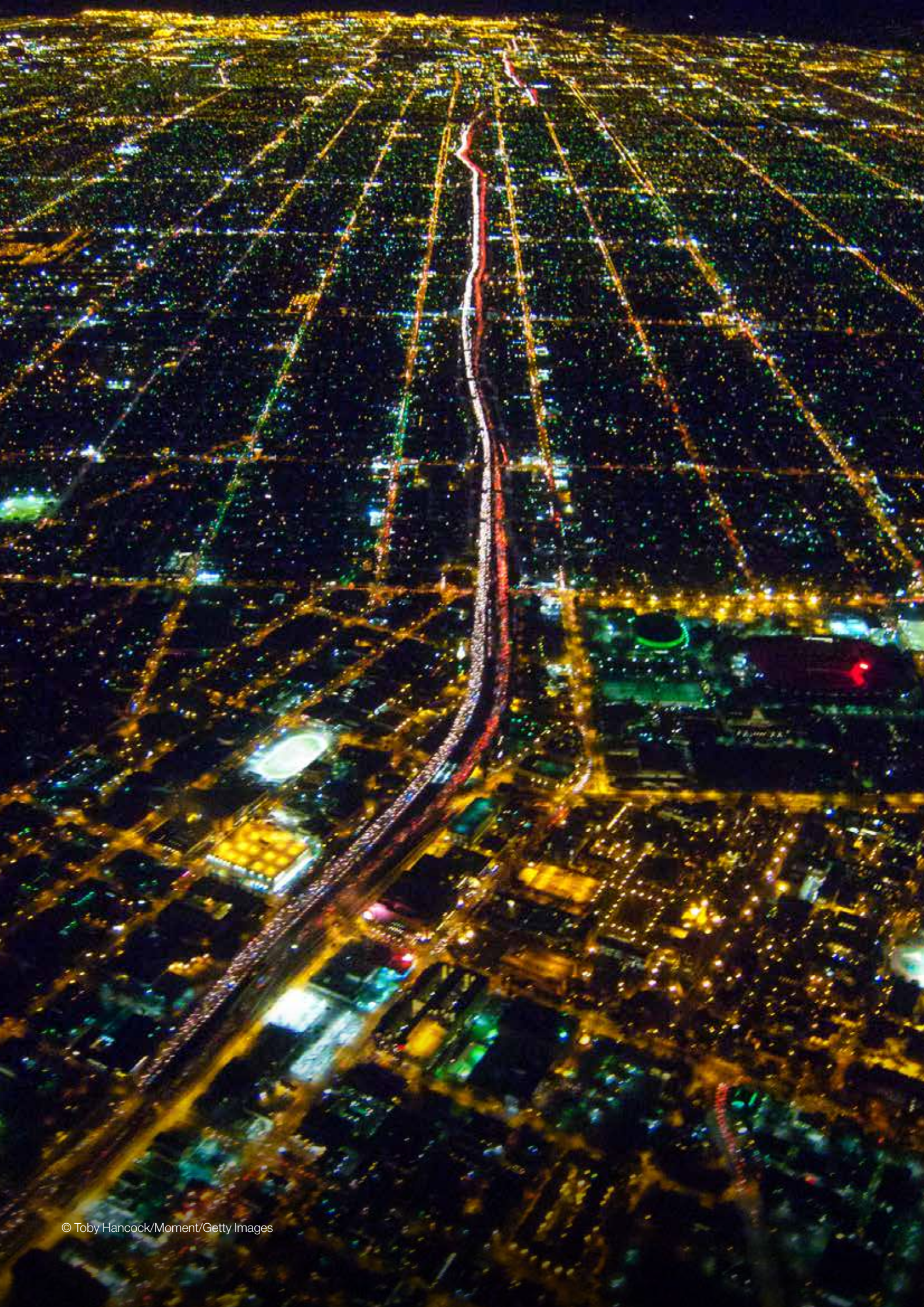
Companies also need to make the right contacts in each city. Even firms that have worked with municipal purchasing departments in the past must engage at a higher level with mayors, city planners, and other decision makers. It will take time to win their trust by proposing mutually beneficial partnerships and engaging thoughtfully about their city's needs. Working with cash-strapped cities often calls for thinking outside the box about how to monetize the solutions they need. Tech companies active in the smart cities space are also increasingly offering financing to cities.

Smart cities have many vocal constituencies and stakeholders. The broader public, whether direct customers or not, can be affected by a company's offerings. City residents and the officials who represent them often have a great deal to say about smart solutions that shape their environment. Companies have to consider not only how their offerings perform but how they affect the public sphere in order to win and maintain a mandate to operate.

•••

Some cities are starting their transformations with inherent advantages such as wealth, density, and existing high-tech industries. But even places that lack these ingredients can set themselves apart with vision, good management, a willingness to break with conventional ways of doing things, and a relentless commitment to meeting the needs of residents. There are many blank canvases for the private sector, nonprofits, and technologists to fill—and above all, individuals should be empowered to shape the future of the cities they call home.

© Didier Marti/Moment/Getty Images



© Toby Hancock/Moment/Getty Images

RELATED MCKINSEY AND MGI RESEARCH

Smart cities: Turning opportunity into reality (December 2017)

In a world where technology is increasingly ubiquitous, it seems every city is a smart city. However, building a smart city means more than hardware deployment. It is about using technology to deliver better outcomes for residents.

An integrated perspective on the future of mobility (October 2016)

This report explores how existing social, economic, and technological trends are converging to disrupt mobility at the local level.

Bridging global infrastructure gaps (June 2016)

Global infrastructure systems are straining to meet demand, and the spending trajectory will lead to worsening gaps. But there are solutions to unlock financing and make the sector more productive.

The age of analytics: Competing in a data-driven world (December 2016)

Big data's potential just keeps growing. Taking full advantage means companies must incorporate analytics into their strategic vision and use it to make better, faster decisions.

The Internet of Things: Mapping the value beyond the hype (June 2015)

If policy makers and businesses get it right, linking the physical and digital worlds could generate up to $11.1 trillion a year in economic value by 2025.

Urban world: Cities and the rise of the consuming class (June 2012)

MGI explores the phenomenon of urban growth, the one billion people in rapidly growing cities who will become consumers by 2025, and how these consumers will affect demand not only for individual products but also for infrastructure.

www.mckinsey.com/mgi

E-book versions of selected MGI reports are available at MGI's website, Amazon's Kindle bookstore, and Apple's iBooks Store.

Download and listen to MGI podcasts on iTunes or at www.mckinsey.com/mgi/publications/multimedia/

Cover image: © Buena Vista Images/Photodisc/Getty Images.

Infographic by Patrick White.

McKinsey Global Institute
June 2018
Copyright © McKinsey & Company
mckinsey.com/mgi

@McKinsey_MGI
McKinseyGlobalInstitute